

USE OF EARTH GRAVITY ASSIST FOR NEAR-EARTH ASTEROID MISSIONS

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ABSTRACT

The NASA emphasis for "faster, cheaper, better" missions for solar system exploration makes near-Earth asteroid (NEA) flybys and rendezvous ideal candidates. This desire is emphasized with the initiation of the Discovery program, which includes a mission to Nereus launched in 1998. Also, the Clementine Mission, an SDI project, will fly a spacecraft to orbit the moon and subsequently be injected to a flyby of Geographos in 1995. More recently, the radar images of Toutatis showing this asteroid as probably a contact binary, and general discussions of asteroid impacts on Earth, have heightened interest in NEAs.

Currently, there are about 200 known NEAs (defined to have orbits whose perihelions lie within Mars' orbit), and about a dozen or so more are being discovered each year. An astrodynamics challenge is to devise missions for single or multiple encounters (flybys, rendezvous, or even sample returns) maximizing payload and science return, and minimizing mission duration.

A survey of low-energy near-Earth flyby missions was presented by Sauer (Reference 1) in 1991. Methods for computing multiple flybys with a single spacecraft and multiple flybys with multiple spacecraft using a single launch, are presented in References 2 and 3. About 2 dozen low energy single NEA flyby opportunities per year exist. Of these, about a half dozen can be combined into double or triple flybys.

These opportunities may be expanded with the use of Earth gravity assist. If one examines the above opportunities carefully, one sees that many of them can be encountered within a year, and in such a way that the spacecraft will then return to Earth. These one-year Earth returns then allow reshaping of the trajectory by the Earth, via gravity assist, so that the spacecraft may be sent to another asteroid, either for a flyby or rendezvous. One result of this paper is to provide a survey of these one-year Earth gravity assist opportunities which yield multiple NEA flybys.

An additional intent of the paper is to discuss the use of Earth gravity assist in a broader perspective. In particular, energy requirements for fractional and integral year returns will be evaluated, as well as their potential use for NEA missions. Examples will be given for the optimum manner in which they may be used. Finally, enhancements (and restrictions) in the additional use of lunar gravity assist will be discussed, and results presented in parametric form. The problem of enhancing mission capability with the use of third-body perturbations (Earth, Sun, Moon) will be addressed at a later date.

1. Sauer, Jr., C. G., "Low Energy Near-Earth Asteroid Flyby Missions," Paper No. AAS 91-398, presented at the AAS/AIAA Astrodynamics Specialist Conference, Durango, CO, August 19-22, 1991.
2. Penzo, P. A., "Rapid Computation of Multiple Near Earth Asteroid Flyby Opportunities," Paper No. AAS 91-527, presented at the AAS/AIAA Astrodynamics Specialist Conference, Durango, CO, August 19-22, 1991.
3. Penzo, P. A., "A Multi-Mission Flyby Strategy for the Near-Earth Asteroids," Paper No. AIAA-92-4374, presented at the AIAA/AAS Astrodynamics Conference, Hilton Head Island, SC, August 10-12, 1992.